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(58) Field of search
UK CL (Edition J) A1E EAAA EAAB EAC EAKX
INT CL⁴ A01G

(54) **Apparatus and method for propagating and growing plants**

(57) A biodegradable carrier (11) for seeds and/or seedlings comprises an open container body (12) defined by a laminar wall (12) at least a part (13) of which is foraminous, the container housing a seed support medium (18) secured into the container (11) by support medium retention means. A seed (21) may be located under the seed support retention means, which is soluble, to allow watering of the medium to initiate germination of the seed. The medium 18 may be particulate, paste, gel or liquid, and the retention means an adhesive forming a skin on the surface of medium 18, a metal foil, or wax layer. A number of carriers may be supported on a tray or a holder strip.

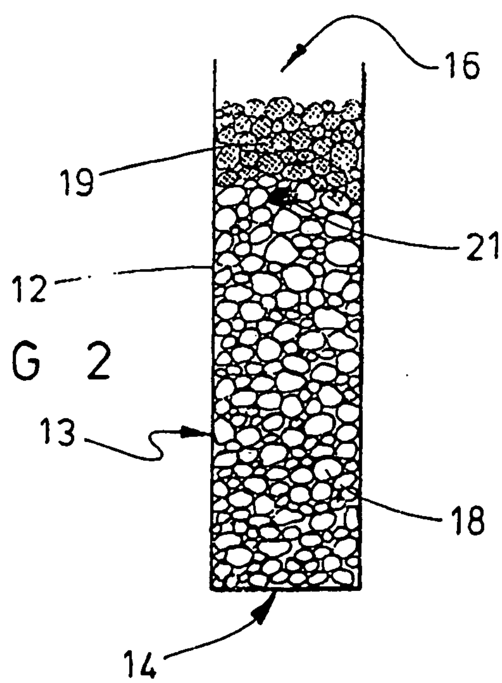

FIG 2

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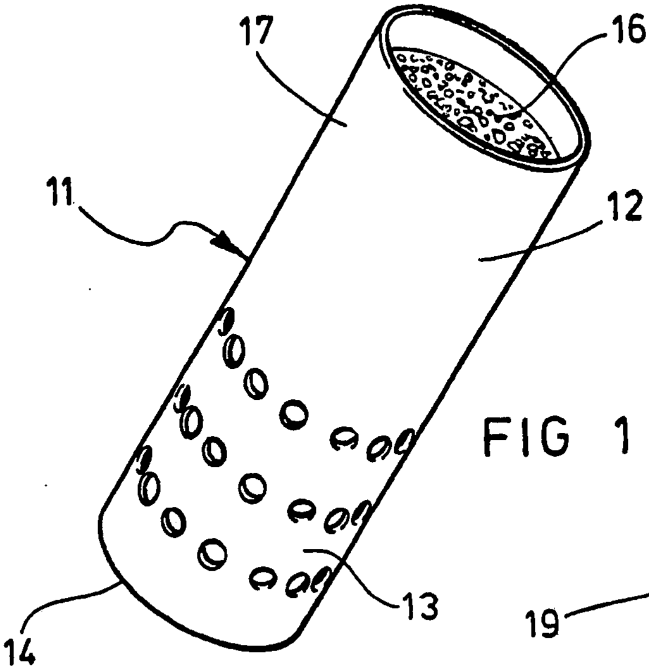

FIG 1

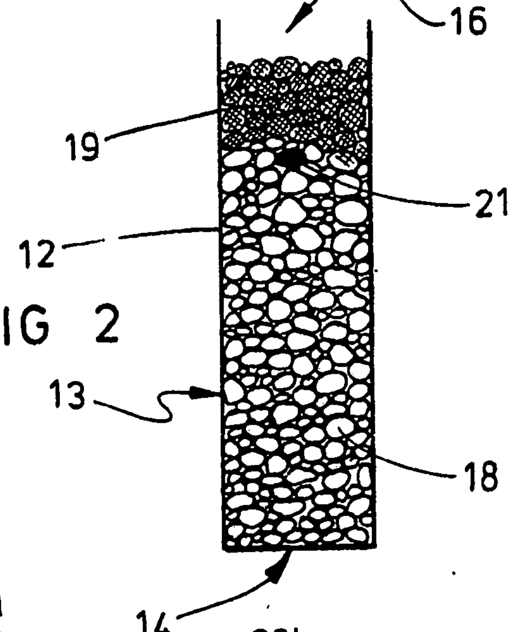

FIG 2

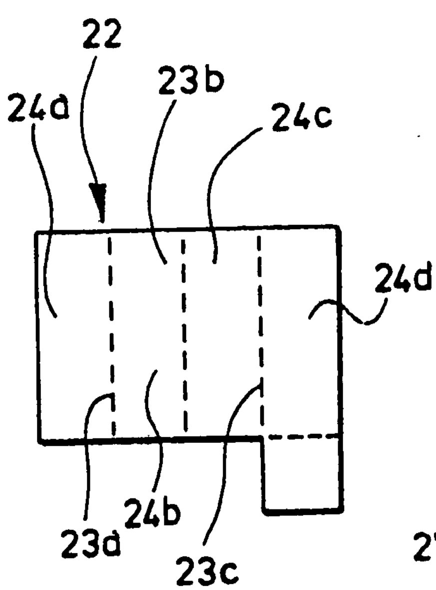

FIG 3a

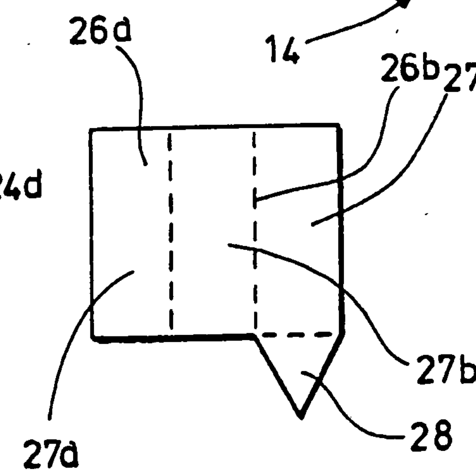

FIG 3b

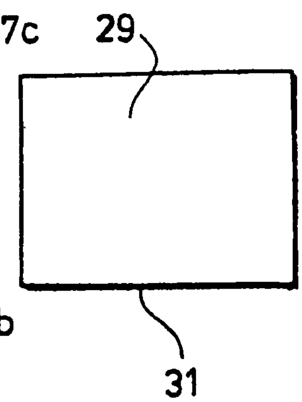

FIG 3c

FIG 3d

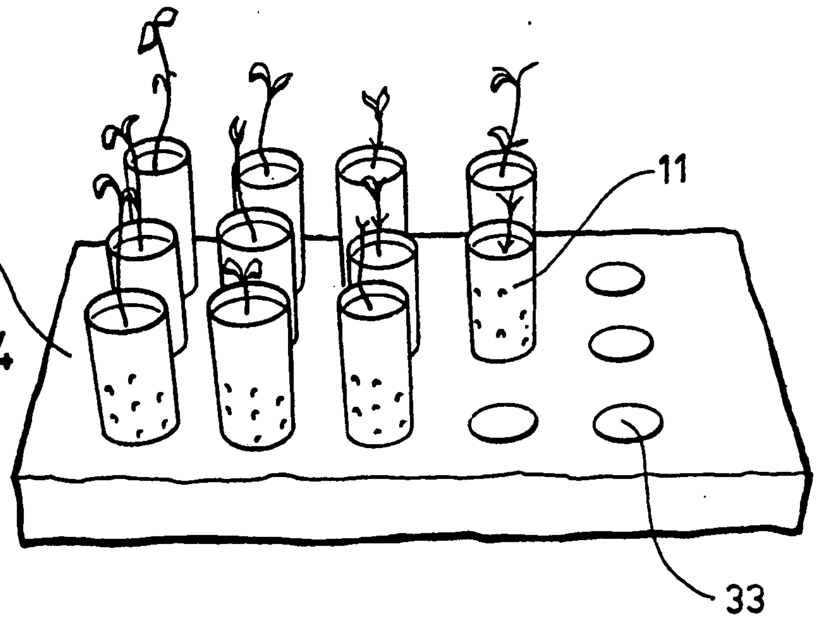

FIG 4

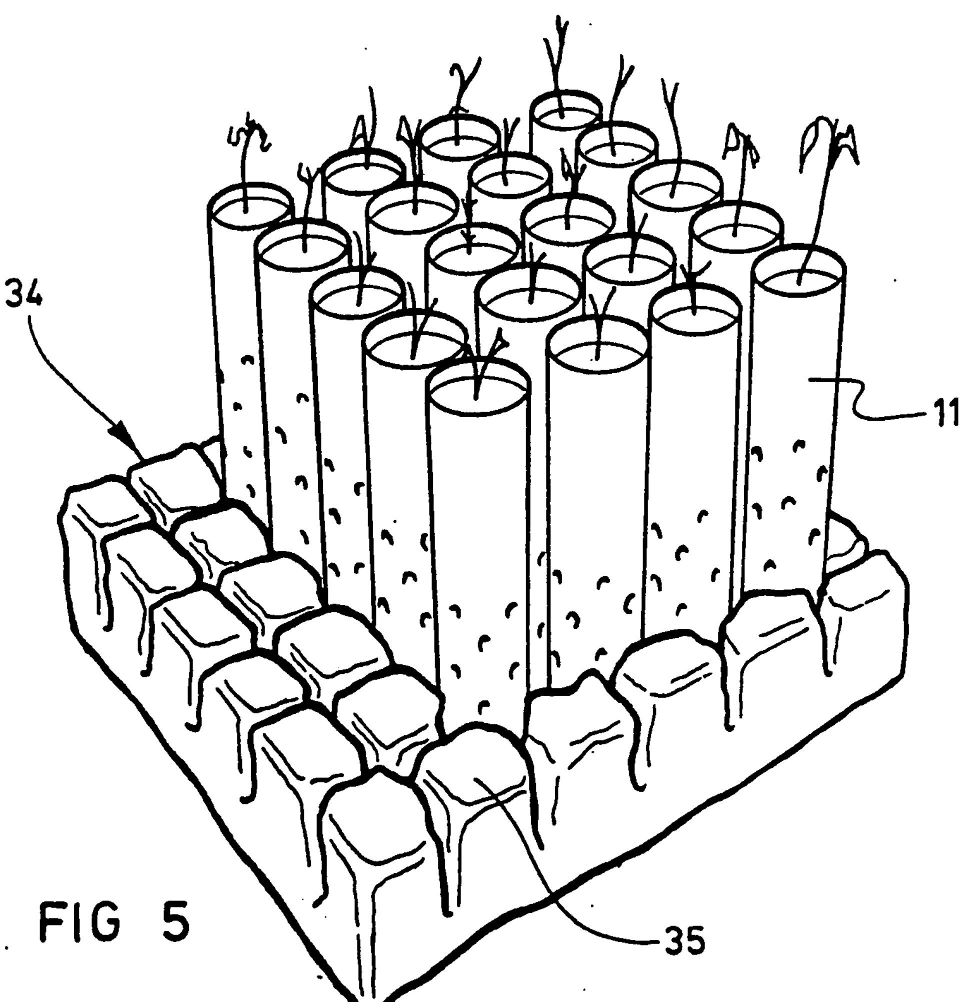

FIG 5

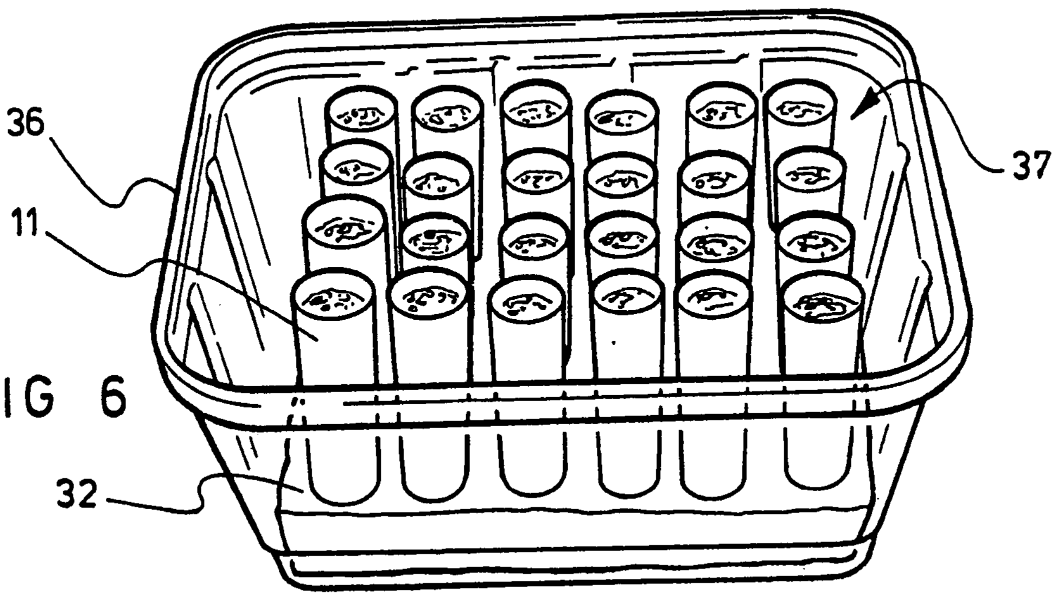

FIG 6

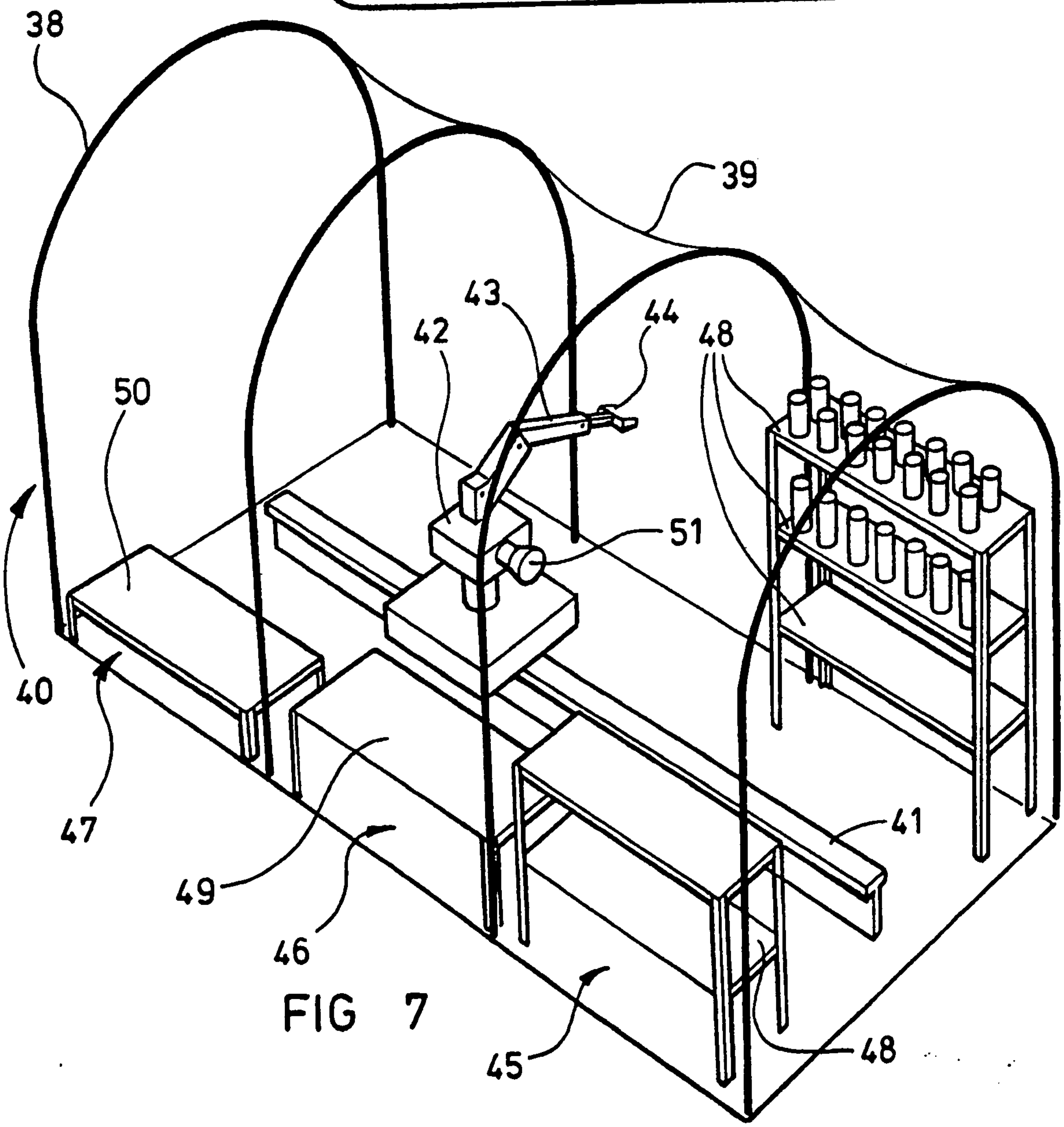

FIG 7

APPARATUS AND METHOD FOR PROPAGATING AND GROWING PLANTS

The present invention relates generally to apparatus for propagating and growing plants. The present invention is applicable to horticultural and/or agricultural application and as used hereinafter the term "plant propagation" will be understood to relate to the propagation of plants suitable for any form of horticulture, agriculture, forestry, viticulture or other specific plant culture. For convenience the term "horticulture" will be used in a generic sense to relate to any more specific plant propagation and/or growing system.

In order to produce plants commercially it is necessary either to collect or otherwise produce seed from which plants normally reproduce, or to take cuttings of existing plants which are then maintained in a controlled environment suitable for growth. The reproduction of plants from seed is fraught with a number of difficulties. First, it is necessary to establish that the seed itself is viable, and to maintain the seed in an appropriate condition to store it ready for use without triggering germination. Such conditions usually involve low temperatures and/or very low humidity levels and such conditions can be maintained with certainty only in

closely controlled environments such as are available in factories or industrial premises. It is also known to produce "new" seed by appropriate operations on existing seeds, such as irradiation and the like, and tests must then be conducted to establish the viability of such "modified" or "new" seed. Other techniques are known to those skilled in the art: such techniques also involve the preservation of seed from attack by disease or other organisms and the importation of seed from other countries is closely controlled in order to ensure that it is not carrying disease to which indigenous plants are susceptible. For the above reasons the supply of viable seed is concentrated in the hands of relatively few large concerns, some of which are also responsible for testing the viability of seed before it can be made available on the open market.

The need for stringent testing is recognised by the authorities and laid down in regulations which take account of the fact that it is extremely difficult to spot any problems in seed samples themselves without first conducting carefully controlled tests.

Apart from these considerations, there are additional problems for would-be propagators. Some species of plants require very specific conditions before their

seeds will germinate and even seed having passed the stringent tests required before they can be made available on the open market still fail to germinate due to the inexperience or inability of the purchasers to maintain the required germination conditions for an adequate length of time.

Another problem which is encountered in the propagation of plants lies in the fact that it is necessary usually to plant seeds in a very fine growing medium which is particularly rich in nutrients of an appropriate type to be taken in by the young root system as it is developing. It is not a practical proposition, however, to prepare a bed of growing medium of sufficient size to receive the fully grown plant to a degree of fineness suitable for seed germination and initial growth. For this reason it is common for seeds to be germinated in "nursery" seed beds maintained in appropriate conditions until the seedlings have developed to a certain stage, whereupon the seedlings are "pricked out" into pots or beds to receive them for a subsequent stage in their growth. In the case of certain plants, such as tomatoes, it is necessary further to transplant the seedlings after they have been pricked out and grown on when the young plants are placed in their final environment where they grown to maturity. Each pricking out or transplanting operation

necessarily disturbs the roots of the plant and causes a set back to growth which effectively limits the maximum development of the plant within a certain period of time, which period is however governed by the climatic conditions and geographical location.

Many plant seeds are extremely small and, except in the case of pelletted seed, which has its own disadvantages of increased cost and additional processing stages, it is practically impossible to sow them at a sufficiently wide spacing as a result of which many plants are lost in the initial pricking out operation due to the fatal disturbance of their root systems. Close sowing of fine seed is also necessary due to the level of viability which results in many seeds failing to germinate. In commercial nurseries where space is at a premium it is obviously essential to make use of as much of the available space as possible and the sowing of individual seeds in the final position is therefore uneconomic. Pricking out and transplanting of seedlings is a tedious and time consuming operation which, apart from the damage which is done to the plants themselves, occupies the nursery staff for an inordinate amount of time and, furthermore, requires skilled, careful and concentrated effort in order successfully to perform. It is not advisable to employ unskilled or casual labour for such

tasks due to the risk of losses by damage to the delicate seedlings. However, because of the seasonal nature of many horticultural operations, the pricking out and/or transplanting operations must all be performed within a relatively short space of time and this places heavy pressures on the proprietor and/or trained staff of the nursery where, at certain parts of the season, an eighteen hour working day is not uncommon.

Modern developments in the production of most goods have tended to centre on automation of routine processes and the transfer of particularly onerous, difficult or dangerous tasks to automatic machinery which can operate continuously throughout the full twenty four hours of the day with a minimum of supervision whilst nevertheless performing the tasks to a degree of precision difficulty for a human operator to achieve. Automatic machinery for materials handling, welding, painting and the like are well known but because of the inherently low value of the end product in horticulture automatic equipment for the difficult tasks such as pricking out or transplanting of plants or seedlings has not been developed, although such equipment for handling plugs (that is seedlings grown in cellular trays), soil blocks (that is blocks of compressed peat-based compost) does exist. Machinery is also available for planting bare-rooted seedlings of

relatively hardy plants such as cabbages and forestry seedlings.

The present invention seeks to provide means by which existing automatic materials handling machinery can be adapted for handling delicate plants and seedlings which have hitherto been manipulated only by hand.

The present invention also seeks to provide means by which the previously onerous task of pricking out and transplanting small seedlings can be avoided. Embodiments of the present invention can be used in such a way as to enable small nurserymen to avoid the task of filling seed trays and actually planting the seeds, which is a considerable advantage especially for nurserymen not equipped with bulk handling equipment.

The present invention also seeks to provide means by which ungerminated seed may be presented to the purchasing public in a manner most likely to result in successful production of plants, and in which transplanting or pricking out of young seedlings is avoided thereby avoiding the set back to growth associated with this process.

According to one aspect of the present invention a

biodegradable carrier for seeds and/or seedlings comprises an open container defined by laminar walls at least some of which are provided with foramen over at least a part of the area thereof, and containing a seed support medium secured into the container by support medium retention means. Such retention means may be at one or both ends of the carrier. Preferably the carrier is phytologically inert.

The seed support medium itself may be one of a number of different forms. In one embodiment of the invention it is anticipated that the seed support medium will be particulate, and it is considered to be especially convenient if the particulate material is a phytologically inert material such as perlite. Other phytologically inert materials are, of course, available and the present invention is intended to comprehend biodegradable carriers incorporating other such particulate materials.

In other embodiments, however, the seed support medium may be of a different form, and in particular may be a paste, a gel or a liquid.

Depending on the form of the seed support medium the support medium retention means may take one of a number

of different forms. The various forms which the seed support medium retention means may take are discussed hereinbelow.

Although the seed support medium may be substantially phytologically inert this is not an essential requirement and a phytologically active seed support medium may be provided and/or a phytologically inert seed support medium may be provided with plant nutrients which may be dispersed, suspended, dissolved or otherwise distributed throughout the seed support medium depending on its nature or form.

In the case of a seed support medium of particulate form as discussed above the support medium retention means preferably comprise an adhesive settable material forming a skin layer over the surface of the support medium. Such a skin layer may in fact be formed by impregnation of an upper stratum of the particulate material by the introduction of an adhesive to the free surface thereof. The adhesive is preferably a water soluble gum which dissolves upon the introduction of water to the container thereby allowing the humidity level in the seed support medium to be varied. The adhesive may, of course, itself contain dissolved plant nutrients which are unavailable to the seed whilst the adhesive is in its dried state

retaining the seed support medium, but which become available to the seed and/or the seedling after germination, once the adhesive is moistened by the introduction of water.

In the case of carriers in which the seed support medium is other than particulate, particularly in the case of a seed support medium in the form of a paste, gel or liquid, the support medium retention means may comprise a mechanically pierceable layer. Indeed, a mechanically pierceable layer may also be provided if the seed support medium is particulate, but is is envisaged that such a mechanically pierceable layer is likely to be most relevant in the case of liquid, paste or gel-like seed support media. One such mechanically pierceable layer which may be used is a layer of foil such as metal foil adhesively secured across the open end of the container constituting the biodegradable carrier. A layer of molten wax would also produce a skin at room temperature to serve the same purpose. Alternatively, however, the mechanically pierceable layer may be a surface layer of the material which has been reduced in temperature to a level where the material itself is solid. Differentially frozen liquid, gel or paste media would, of course, require to be maintained within rather close temperature limits, but such environments may be readily made

available on an industrial scale. Even in the case of particulate material seed support media it is possible for an upper stratum of the particulate material to be saturated and then frozen in order to maintain the material within an otherwise open container.

The present invention also comprehends a biodegradable carrier for seeds and/or seedlings as defined hereinabove as the seed and/or seedling is present in the support medium. Such a carrier makes available many concepts previously unknown. First, each individual carrier, because it is biodegradable and has foramenous walls, may be treated as an individual seed or plant so that when placed in appropriate environmental conditions germination and/or propagation of the plant in question will follow. After a minimum amount of seed development, that is when the seedling may still be too small to be handled conveniently in a conventional system, and in which, in a conventional system, it would be normal to expect a large number of similar such seedlings to be growing together closely confined in a seed bed, it is possible to handle the seedling without damage by acting on the external walls of the carrier, and in particular to place the carrier into a further growing medium into which the roots of the seedling may pass through the foramen in the side walls of the container. After a

period of time the walls of the container break down by biological action and leave no polluting or harmful residue in the growing medium. Indeed, the walls of the container themselves may be made of a material incorporating plant nutrients such that, upon transplanting into a growing medium, the plant finds itself surrounded by a growing medium enriched with appropriate plant nutrients for its own requirements. Other chemicals may be impregnated into or formed as surface layers on the container, in particular fungicides, molluscicides or the like capable of protecting the seedling from attack by damaging agents or predators.

Further, it is now open to commercial enterprises to germinate seeds which require very special environmental conditions, and then to sell the germinated seeds, as a very small seedlings, to the general public the members of which then have a much greater chance of successfully growing such plants than has hithertofore been the case when purchasing seeds. The cost of producing germinated seed is only marginally greater than the cost of the seed itself, however, and accordingly germinated seed can be made available on the market at a cost only slightly greater than ungerminated seed but with the advantages that the chances of successful growth of the desired

plants are much greater than with ungerminated seed.

It is further possible for enterprises to make available containers for seed without providing the seed in the container, so that individual horticulturalists, or amateurs, may seed their own containers to their own requirements.

One suitable material for making the walls of the container of a biodegradable carrier comprises waxed paper which, in addition to be biodegradable, is relatively non toxic, easy to manufacture and readily obtainable. Furthermore, it is low in cost and susceptible of industrial processes such a thermoforming, cutting, folding and can be held in shape by self-welding. A suitable particulate material for filling such containers comprises perlite which, again, is readily available.

A further variable which is available using the biodegradable carriers of the present invention, lies in the degree of light which may be allowed to fall on seeds whilst in the seed support medium. By making the carrier walls of a transparent or transluscent material it is possible to germinate seeds in an illuminated environment where this is found to increase the germination rate.

Opaque materials may be used, however, for the container walls for seeds requiring a light-free environment for germination, and germination may then proceed regardlessof the external illumination level which may be maintained for other purposes, for example for staff to be able to perform operations on nearby plants and/or equipment. After germination has taken place and the seedling is emerging from the soil a much greater level of illumination is required even than that provided in a normal working environment in order to avoid etiolation.

According to another aspect of the present invention apparatus for germinating and/or propagating seeds and/or plants comprises an array of carriers as defined hereinabove, together with means for controlling the environmental conditions around the carrier whereby to initiate germination and/or propagation.

The environmental conditions may comprise temperature, humidity, light level, pressure as well as nutrient content of the growing medium and nutrient availability.

An array of carriers in such a system may be a one-dimensional array, with the carriers being supported on a generally planar strip-like holder element, or alternatively the array may be a two-dimensional array,

with the carriers being supported on an underlying holder of appropriate form. Various different forms of holder may be used with the carrier arrays of the present invention. Conveniently, the holder may be in the form of a tray with a plurality of recesses or sockets for receiving respective carriers. Alternatively, however, the tray may be made of a flexible material with a plurality of upstanding bosses or separators, between which respective carriers may be introduced to be held in place thereby. Rigid or semi-rigid materials may be used if the carriers are made from a material able to deform slightly upon insertion.

Arrays of carriers may then easily be handled for any of the processes which may be performed on them. For example, arrays of carriers may be presented to a machine for introducing seeds into the seed support medium of the carrier, and in this way arrays of carriers each carrying a respective seed ready to germinate may be produced. By the use of appropriate machinery and/or colour coding of the carrier walls, it is possible for different sets of seed to be sown into different individual carriers within an array so that a mixed collection of seeds may be presented to the end user. The greatest degree of convenience and speed in operation will be experienced when the seed sowing machine is able to act with a single

class of seed on successive arrays of carriers, however, although it is not impossible that seed sowing machines capable of sowing with great accuracy individual seed into respective carriers may be developed. The critical aspect which the present invention addresses is the provision of individual volumes of seed support material in accurately defined physical positions. An array of carriers for receiving seeds can thus be viewed as a high precision component in a horticultural engineering system.

Further, subsequent operations to be performed on plants during growth can be effected entirely automatically and, with the system of the present invention, the production of plant products such as flowers or fruit in an entirely automatic manner is entirely possible. The seeds may be introduced into the carriers by automatic machinery and the arrays of carriers then conveyed by robot machines to germination stations where there are appropriate optical means for detecting germination and controlling the transfer of individual carriers or arrays of carriers from the germination station to a further part of the installation where conditions for plant growth are maintained at an appropriate level for the development of the plant. It is known that the natural development of plants has resulted in a requirement for different

conditions, matching those of the typical seasons encountered in the locations where they are indigenous, and these may be reproduced in an entirely automatic installation by slowly conveying arrays of carriers housing respective plants through successive areas where different environmental conditions are maintained. Immediately after germination, therefore, the array of carriers may for example be transported through an area where relatively cool moist conditions are maintained to simulate those encountered in spring and early summer. During their sojourn in this controlled environment the plant development can be optically monitored and once each individual plant reaches a certain stage of development automatic handling machinery may separate the carrier from the array, by gripping the walls of the carrier and therefore without damaging the seedling in any way, and transfer it to a prepared larger container or a bed where the plant is to be grown to maturity. Such transfer can be achieved without disturbing in any way the growth of the root system of the plant and no set back is experienced by this operation.

Passing on then into the new area the conditions here may be warmer and drier than in the first, initial growth area, whereby to encourage full development of the plant. By making an entirely closed environment the atmosphere

may be filled with chemical agents toxic to unwanted parasites or pests, and in particular sprays of fungicide or insecticide may maintain a level within the closed environment greater than that which would be tolerable if there were human operators within the system. Such an arrangement is possible, however, due to the entirely automatic operation of the system and it is envisaged that a continuous fungicide and/or insecticide atmosphere may be more effective, particularly to avoid the build up of resistance, than the occasional highly intense sprays which are currently used in manned growing environments such as greenhouses.

According to another aspect of the present invention, therefore, an automatic plant propagation and development system comprises a plurality of carriers as defined hereinabove held in separate arrays on a plurality of holders, with automatic control apparatus for determining environmental conditions such as growing medium nutrient content and availability, temperature and humidity, at least two different zones with different environmental conditions, and automatic means for conveying selected carriers or arrays of carriers from one zone to another.

The optical means for testing germination and/or plant growth may include colour sensitive detectors operable to

produce electrical signals when the area of green or other colour within their field of view exceeds or falls below a predetermined threshold value, for example representing a predetermined leaf area within the volume.

Various embodiments of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a carrier formed according to the present invention;

Figure 2 is a cross-sectional view through the carrier illustrated in Figure 1;

Figures 3a, b and c are developed views of blanks suitable for forming various different embodiments of carrier;

Figure 4 is a perspective view of a holder for supporting an array of carriers;

Figure 5 is a perspective view of an alternative form of holder for supporting an array of carriers;

Figure 6 is a perspective view of a propagation system incorporating the carriers of the present invention; and

Figure 7 is a schematic view of an entirely automatic plant germination, propagation and harvesting

system employing the principles of the present invention.

Referring first to Figures 1 and 2, the carrier shown comprises an upwardly open tube-like container 11 in the form of a three dimensional body made from a laminar element by folding or rolling to define an interior volume enclosed by a skin of the laminar material and open at one end to receive contents.

In the embodiment illustrated in Figures 1 and 2 the carrier is formed as a right cylindrical tubular wall 12 made from waxed paper having a plurality of perforations 13 in the vicinity of a first end 14, which is closed. At the opposite end 15 of the body 12 the carrier 11 has a substantially unobstructed opening 16 and the wall portion of the tubular body 12 in the region of the carrier opening 16 is imperforate and identified with the reference numeral 17. The apertures in the foraminous or perforated wall portion 13 are sufficiently large to allow rootlets and excess water to pass through the wall of the tubular body 12 without hindrance. In another embodiment (not shown) the tubular wall 12 is formed by helically winding an elongate strip. The apertures or foramen need not be restricted to the lower end as shown but may be provided over the whole of the surface area depending on the conditions to be created for the

seedling.

The embodiment shown is intended to receive a single seed to be grown into an individual plant and for convenience is made to standard dimensions of 50 millimetres length and 10 millimetres diameter. It is to be understood, however, that these dimensions are not limitative, and embodiments of the present invention may equally well be made to different dimensions.

Turning now specifically to Figure 2, the body 12 of the carrier 11 is filled with an interior charge of perlite granules 18 to within a short distance of the open end 16, and a free surface portion 19 of the charge is impregnated with a water soluble non-phytotoxic gum which, when dry, forms a solid plug in the upper portion 19 of the charge. The gum is identified with the reference numeral 20 and its presence ensures that the otherwise loosely filled charge of perlite granules 18 within the interior of the cylindrical body are retained securely to enable the carrier 11 to be handled by automatic machinery without spillage, and to be transported in any orientation.

In the embodiment illustrated a seed 21 is shown in position within the charge just below the free surface

portion 19 impregnated with the gum 20. The seed 21 may be introduced into the carrier opening 16 after only part of the charge has been placed in the tubular body, and the remainder of the charge then positioned over it. Once the gum has been introduced and allowed to set the seed 21, the charge 18 and the free surface portion 19 are all retained in position and sealed against contamination.

The choice of waxed paper for the tubular body in the embodiment described above has been made because this material is biodegradable, relatively non-toxic, easy to fabricate into tubular bodies and cheap and readily available on the market. Tubes formed of such a material can be secured by self-welding, using heating blades, and once formed into tubular or prismatic bodies the carriers 11 are sufficiently rigid to be handled easily by machinery or hand. Furthermore, utilising dimensions such as are indicated by way of example above, namely the tubular carrier 10 millimetres in diameter by 50 millimetres long, it is possible to produce in the region of 450 tubular carriers from one square metre of waxed paper and, with the same dimensions, 100 litres of perlite will be sufficient to charge in the region of 35000 carriers.

Once filled, sealed and assembled, the tubular carriers may be stored dry for a considerable period and the manufacturing machinery may thus be operated continuously throughout the year despite seasonal fluctuations in demand. Furthermore, because a single dimension or a small range of dimensions of the product are required, a single industrial unit with a small complement of staff may produce a very large number, running into millions of carriers, each year. In addition, the choice of waxed paper as the material results in a low unit weight which allows the product to be used with machinery having relatively small prime movers, such as small stepping motors.

Of course, alternative materials for manufacturing the tubular body may also be employed, for example craft paper, flexible laminar biodegradable plastics, fibre board, compressed peat sheets and the like although production techniques for producing carrier elements from such materials will be different from those for producing such elements from waxed paper.

Regardless of the nature of the material, appropriate identification codes may be marked on the surface of the cylindrical body 12, for example by direct printing onto the material, or by the application of biodegradable

labels. Any form of information may be applied, for example, trade marks, plant identification symbols, security codes (which may be in the form of bar codes or other indicia) and marking of the cylindrical body after it has been formed to shape may be performed at high speed using any known technique, for example ink jet printing. Simple colour coding of one end of the tubular body 12 or the provision of a plurality of coloured rings may also be employed in a system similar to the colour coded value-identifying rings on electrical resistors. The manner in which the indicia are applied to the body 12 is non limiting, and in addition to marks placed on the underlying paper or substrate, the wax coating layer may itself be dyed or printed and, in addition, as outlined above either the substrate or the wax may be impregnated with chemical compositions for effecting specific functions during growth of the seed contained within the carrier, for example fungicides, nutrients, molluscicides and the like. Likewise, the charge of granular material may itself be admixed or impregnated with chemicals such as those referred to above as well as soluble release agents activated during watering to make nutrients available to the seed or seedling during growth. Alternatively, such chemicals may be incorporated into the gum sealing the particulate or granular charge as well as or instead of dispersion or

incorporation into the charge itself.

Tubes such as those illustrated in Figure 1 and Figure 2 may be sold empty, may be filled with a charge of material ready for subsequent seeding, or, as shown in Figure 2, may be pre-seeded so that the product sold comprises not only a carrier, but also a seed which, in the circumstances outlined hereinabove, may itself be germinated and/or grown to seedling size prior to sale.

Figure 3 illustrates three blanks which may be used to form prismatic bodies suitable for use as carriers. Figure 3a illustrates a blank 22 of generally rectangular form separated into four narrow strips by three parallel fold lines 23a, 23b and 23c: one of the strips 24 separated by the fold lines 23 is longer than the others by the width of the strips, which are all of equal width, so that when the blank is folded along the three fold lines 23 the projecting tab can be folded over to form a base. Suitable gum or other adhesive may be used to hold the folded blank into its shape as a square-section tube and tabs or other overlying elements (not shown) may be provided also for this purpose.

Figure 3b shows a similar blank 25 having two fold lines 26a, 26b separating three rectangular strips 27a, 27b and

27c the latter of which has a triangular projection. The blank 25 can be folded along the fold lines 26 to form a triangular-section prismatic body closed at one end by the flap 28.

Figure 3c illustrates a blank suitable for forming a tubular cylindrical body such as that illustrated in Figures 1 and 2, in which the closed end 14 is formed by folding two arcuate, arcuate segmental end portions inwards to overlap as suggested in Figure 3d. The blank 29 is thus a plane rectangle and the segmental arcuate portions 30 are not specifically defined on the blank but formed at any point along one of the longer edges 31 by appropriate instruments once the blank 29 has been rolled into a tube.

Whether the carrier is formed as a circular section, square section or triangular section prismatic body the principles of use of the carrier are identical. Indeed, it must be emphasised that the illustrated examples of suitable prismatic forms are presented purely by way of non-limitative example only, and many other shapes may be used, including regular and irregular polygonal sections. There are advantages in interrupting the tendency of roots to grow round and round inside a tube rather than seeking to escape (which is the ultimate objective) and

thus any folds or internal projections (such as burrs left by perforations of the holes) may help in this regard.

Referring now to Figure 4 there is shown a support or holder 32 in the form of a rectangular tray having an array of shaped recesses or sockets 33 for receiving the closed ends 14 of respective carriers 11. In this case the recesses 33 are circular for receiving carriers 11 such as those illustrated in Figures 1 and 2. In this embodiment the holder 32 is formed as a rectangular block of absorbent rigid foam material having an array of circular blind holes formed in a major face, into which respective carriers 11 can be introduced. Such carriers are sufficiently rigid to allow mechanical handling in nurseries and/or can be readily packaged to present the product to the retail customer. Although Figure 4 illustrates a holder having apertures for receiving only twelve carriers holders of any size and having any number of apertures or recesses 33 may be provided. Conveniently, holders with five rows of ten apertures may be formed as a standard unit allowing presentation of carriers to automatic equipment in multiples of five or ten depending on the direction of feed.

The gum-impregnated free surface portion 19 of the charge

18 within the carrier 11 acts as a small reservoir within the tubular walls of the carrier 11 when initial watering takes place. Until the gum dissolves this holds a small amount of water until complete softening of the gum has taken place, following which drainage of surplus water through the perlite takes place allowing the perlite charge to become dampened right through.

Although it is envisaged that holders carrying a number of carriers 11 may be handled using automatic mechanical handling equipment, unorthodox transport systems, including the floating of holders on the surface of pumped water within channels or pipes may be contemplated.

Because the holders can be produced with the recesses 33 at an accurate spacing, and because the carriers 11 are of a standardised size the carriers may be presented to a machine adapted for automatic seeding (in the case where, unlike in Figure 2, the carrier is charged with a perlite filling but unseeded) which allows automatic seeding to take place at high speeds using known seeding and indexing machines. Seeding may be carried out using individual seeds or fluid drilling into the tubular carriers, either before or after, or during the application of gum. Back filling over seeds is simple to

achieve utilising automatic machines.

Turning now to Figure 5, an alternative holder 34 formed as a rectangular block of material with a plurality of bosses 35 is illustrated. Here, the carriers 11 are held in place by fitting them between adjacent bosses and although they may not be retained as securely as in the case of the embodiment of Figure 4, the production costs of the embodiment of Figure 5 may be sufficiently smaller to make the reduction in security acceptable.

Holders containing any number of carriers 11 may be produced, seeded or unseeded and, indeed, it is possible that carriers 11 may be transported in bulk since the presence of the gum impregnating the free surface layer 19 makes it quite safe for the carriers to be transported in any orientation.

A major advantage of the carrier of the present invention lies in the fact that individual seeding can take place which avoids the necessity for pricking out and subsequent thinning especially in the case of very small seed. The use of casual and unskilled labour is thus made possible because individual carriers can be handled without check to the growth of a germinated seedling and no special precautions have to be taken in doing so.

Automatic pot and tray filling lines actuated by robots may thus be introduced giving greater flexibility during seasonal peaks.

Transplanting seedlings from holders in which they have been germinated into beds can be achieved without the need for training since the carriers simply have to be removed from the holders and placed into appropriately shaped holes which can be made by a simple instrument or by an automatic machine. When warded into place plant growth can continue unchecked. Because it is the carriers and not the plants which are handled, pricking out may be performed by automatic machinery capable of gripping the cylindrical wall of the carrier and because these are a standard size and resistant to significant forces, gripping of the carrier for transplanting a germinated seed or delicate seedling presents no problems even if the seedlings are extremely small as in the case of begonias, or extremely sensitive to disturbance. The success rate in pricking out can be anticipated to approach 100% and this will mean that pricking out into final positions is possible and thinning out will no longer be necessary. Moreover, because there is no check to growth pricking out can take place immediately after emergence so that the space within the germination or propagation volume can be used more efficiently by

replacing germinated seeds with fresh ones individually without having to wait for the tardy developers to germinate.

Figure 6 illustrates a simple propagator which may be used by amateurs with the carriers of the present invention. Here, a simple transparent rigid plastics container 36 with a flat transparent lid 37 houses a holder 32 such as that illustrated in Figure 4 with twenty four carriers 11 such as illustrated in Figures 1 and 2. In use a small amount of moisture is placed into the top of each carrier 11 and the lid 37 is placed onto the container 36 which is then placed in a warm environment for the seeds to germinate. Once germinated they can be individually removed from the propagator and planted out either into a finished location or to an intermediate location for further growth before final transplanting.

Moisture-sensitive chemicals may be incorporated into the material of the carriers 11 to indicate the ph value and/or the watering status of each individual carrier within the propagating container. Further, expensive hybrid seed may be sold in individual tubular carriers incorporating the appropriate plant nutrients within the granular charge so that the best possible chance of

germination is obtained. Rare and expensive seed is thus utilised with maximum effect and only germinated seeds become transplants, which is an important consideration during the production of plants from difficult seeds, for example in the growing of freesias. Further, although a single homogenous charge is illustrated in Figure 2, it will be appreciated that a multiple layer charge having different materials may be introduced into the carrier body 12 so that precisely the right conditions are encountered by the emerging rootlets as the seed 21 germinates.

On an agricultural scale, a plurality of carriers 11 may be supported on belts, webs or strips of biodegradable plastics material permitting a high speed of working. Such assemblies, coiled to take up the minimum amount of space, may be germinated in appropriate conditions and subsequently introduced into the ground at accurate centres using techniques similar to those currently employed for burying pipes or cables. One machine with a single operator may be used to introduce a plurality of such strips at high speed.

Although shown entirely closed at the bottom 14, different configurations at the bottom of the tubular body 12 may be incorporated for specific purposes. By

sealing the bottom 14 with no perforations tap rooting is discouraging whereas the arcuate segmental folding illustrated in Figure 3d allows penetration where such is required and, as mentioned above, embodiments open at both ends may also be produced. By closing the lower end with wax, for example, this may also act to secure the tube in place on a flat surface thus avoiding the need for trays or base blocks such as those illustrated in Figures 4 and 5. Likewise, the area over which the perforations 13 are formed may be varied in dependence on the nature of the seeds to be introduced so that surface rooting is encouraged or discouraged as appropriate.

Referring now to Figure 7 an overall automated system for propagating seeds, transplanting them into an intermediate "nursery" environment and subsequently transplanting into a final environment for fruiting or other cropping growth is illustrated. It will be appreciated that the illustrated example is a single example of the many arrangements which may be made available using the techniques outlined herein. In the example illustrated in Figure 7 a greenhouse of the "tunnel" type is shown comprising a plurality of semi-circular hoops 38 covered with a transparent, typically plastics, skin 39 to form a generally rectangular plan form greenhouse 40. Parallel to the

long edge of the greenhouse, and running through the middle of the greenhouse is a rail 41 for a robot 42 having a robot arm 43 with a gripper 44 at the free end.

The greenhouse 40 is divided into three sections, comprising a propagator section 45, a nursery section 46 and a main growing section 47. The propagator section 45 is maintained at a relatively high temperature and humidity level whilst the nursery section 46 is maintained at a warmer temperature level than the main growing section 47 and at a higher humidity level than the latter. Shelves or racks 48 line the sides of the propagator section of the greenhouse 40 to receive trays of holders each supporting a plurality of carriers such as that illustrated in Figures 1 and 2. Similar racks 49 are positioned in the nursery section 46 whilst the main growing section 47 has a single trough or bed of growing medium 50 on each side of the rail 41. The robot 42 is provided with optical detection equipment 51 by means of which it can scan the rows of carriers on the racks 48 to determine which, if any, have germinated. This may be achieved using simple colour filters so that the camera 51 can produce an output signal when focussed on an emerging plant having green leaves, and the signal generated thereby may trigger the robot to perform appropriate movements to lift the carrier bearing the

germinated seedling from the rack 48 and to transport it to an available position on one of the racks 49 in the nursery section. The robot 42 may be provided with appropriate computers for maintaining a check on those available locations within the nursery rack occupied by carriers having germinated seedlings, and likewise to maintain a record of those available locations in the holders on the propagator racks 48 available to receive newly seeded, but ungerminated carriers when such are presented from time to time.

Additional optical equipment (not illustrated) may be used to detect when the seedlings have grown to a predetermined size in the nursery section 46, for example by directing a beam of light at a certain height and detecting the source of reflected light within a predetermined range. The mechanical technology for effecting such operations is already available and may be determined by those skilled in the art. Once the seedling has grown to a predetermined size the robot 42 acts to withdraw the carrier bearing this seedling from the nursery rack 49 and transfers it to its final transplanted position in the bed 50 in the main growing area 47. All of these processes take place without any check to the growth of the plant since it is moved from place to place within the carrier 11 without damage to

its roots. Furthermore, because no human operator needs to enter the enclosed environment within the greenhouse 39 fungicidal or insecticidal atmospheres may be maintained at all times and the heating level may be selected solely to be that appropriate for the propagation and growth of the plants therein.

Alternative more sophisticated control technology may be used, allowing robotic transfer of whole trays rather than individual carriers, and the use of close-up television monitoring with push button or joy stick control by a remote operator allowing these to be positioned in an office-like environment. Television monitoring may also be used to effect remote checking of the seedling process within the germination chambers. Infra-red and other techniques may likewise be used for the detection of problems with the growth and/or propagation of seedlings to bring them to the attention of the supervising staff before them become apparent to the naked eye. Automatic equipment for local treatment of the environment and/or the growing medium (or indeed the plants themselves) may be provided, again remote controlled where necessary.

Although a tubular body 11 closed at the end 14 is illustrated in Figures 1 and 2 it is, of course, possible

to construct embodiments of the invention in which the tubular body is open at both ends with the intention of closing or sealing each end with a settable glue or wax in the same fashion as is illustrated for the open end 16 in the embodiment of Figures 1 and 2. This would have the advantage that roots could be encouraged to pass out through the open bottom of the tube in circumstances where this is preferred for the particular plants concerned.

CLAIMS

1. A biodegradable carrier for seeds and/or seedlings, comprising an open container defined by a laminar wall which is foraminous over at least a part of the area thereof, and containing a seed support medium secured into the container by support medium retention means.

2. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which said seed support medium is particulate.

3. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which said seed support medium is a paste.

4. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which said seed support medium is a gel.

5. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which said seed support medium is a liquid.

6. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which the said seed support

medium is substantially phytologically inert.

7. A biodegradable carrier for seeds and/or seedlings, as claimed in any preceding Claim, in which plant nutrients are dispersed, suspended, dissolved or otherwise distributed throughout the said seed support medium.

8. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 1, in which the said seed support medium is itself a phytologically active medium.

9. A biodegradable carrier for seeds and/or seedlings, as claimed in any preceding Claim, in which the said seed support medium retention means comprise an adhesive settable material forming a skin layer over the surface of the said seed support medium.

10. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 9, in which the said adhesive settable material is a water soluble gum.

11. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 9 or Claim 10, in which the said adhesive settable material contains dissolved plant nutrients.

12. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 9 in which the said support medium retention means comprise a mechanically pierceable layer.

13. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 9, in which the said support medium retention means are frozen.

14. A biodegradable carrier for seeds and/or seedlings, as claimed in Claim 9, in which the said support medium retention means comprise a layer of metal foil.

15. Apparatus for germinating and/or propagating seeds and/or plants, comprising an array of carriers as claimed in any of Claims 1 to 14, and means for controlling the environmental temperature and humidity.

16. Apparatus for germinating and/or propagating seeds and/or plants, as claimed in Claim 15, in which the array is a linear array with the carriers supported on a generally planar strip-like holder element.

17. Apparatus for germinating and/or propagating seeds and/or plants, as claimed in Claim 15, in which the array is a two-dimensional array with the carriers supported

endwise on an underlying holder.

18. Apparatus for germinating and/or propagating seeds and/or plants, as claimed in any of Claims 15 to 17, in which the said holder is a tray with upstanding separators.

19. Apparatus for germinating and/or propagating seeds and/or plants, as claimed in any of Claims 15 to 17, in which the said holder is a porous block with sockets for respective carriers.

20. An automatic plant propagation system comprising a plurality of carriers as claimed in any of Claims 1 to 19, and held in separate trays or a plurality of holders, with automatic control apparatus for determining environmental conditions such as growing medium nutrient content and availability, temperature and humidity, at least two different zones with different environmental conditions, and automatic means for conveying selected arrays of carriers from one zone to another.

21. An automatic plant propagation system, as claimed in Claim 20, including means for automatically removing selected carriers (with seedling) from holders and transferring them into prepared holes in a growing medium

to allow plant roots to pass through the foraminous wall portions of the carriers into the growing medium.

22. An automatic plant propagation system, as claimed in any preceding Claim, including automatic means for testing germination and/or plant growth rate.

23. A biodegradable carrier substantially as hereinbefore described with reference to, and as shown in, the accompanying drainwgs.

24. Apparatus for germinating and/or propagating seeds substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

25. Automatic plant propagation system substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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